during an accidental fall into the surface impoundment. Iron is the chemical of concern for the risk to trespassers. The incidental ingestion of iron from leachate seep water, also drives the risk to trespassers.

The baseline risk assessment determined that indoor air exposures by inhalation of landfill gas and groundwater volatiles pose a significant risk via chronic exposure to future residents living in the soil borrow pit area, adjacent to the western edge of the landfill site. The contaminants of concern that drive the noncarcinogenic risk include chlorobenzene and toluene. Benzene and vinyl chloride drive the carcinogenic risk.

A number of quantitative assumptions were made in the risk assessment, which resulted in uncertainty associated with the presumed exposure conditions. Among these is the use of maximum detected concentrations for some chemicals and some media for which data sets were limited.

Methane gas concentrations, as determined during the Rl, may present a risk to public safety should housing development occur within the soil borrow pit. Levels of methane were detected in the pit area in excess of the lower explosive limit for methane.

The analysis of risk associated with the landfill site included using the data collected during the RI, computer modeling, and scientific literature reviews. Certain assumptions underlying any human health risk assessment introduce some uncertainty into the results and conclusions. This uncertainty is generally due to numerous variables associated with individuals. To compensate for uncertainty, conservative assumptions are often made which tend to overestimate rather than underestimate risk. Overall, the conservative assumptions in this baseline risk assessment are thought to result in a risk estimate that exceeds the actual site-specific risk. In other words, due to the conservative assumption, the actual risk from the site may be less than estimated. The contamination or chemicals of concern associated with the landfill site, although possessing a risk to human health and the environment, can be adequately remediated.

Groundwater was not identified in the Baseline Risk Assessment as a primary media of concern for human health or ecological pathways. The groundwater between the landfill and the Kishwaukee River is not presently, and is not likely in the future (due to institutional controls and property access restrictions), to be used as a potable water supply. As documented by data collected during the RI, the groundwater downgradient of the landfill Site discharges to the Kishwaukee River. However, the RI groundwater sampling determined that contaminated groundwater from the landfill is not currently impacting the river. The potential does exist, however, for contaminated groundwater impacting the surface water quality of the river. It should be noted that the Kishwaukee River is not a source of potable water supplies. Therefore, the potential human health concern is related only to the consumption of aquatic species (i.e., fish) from the river. Given the above, the protection of the surface water quality and the ecology of the Kishwaukee River is the primary concern with respect to groundwater remediation. Therefore, groundwater action levels have been established to be protective of surface water

quality.

Section 3: Toxicity Assessment

The purpose of the toxicity assessment is to review toxicity and carcinogenicity data for the Chemicals of Potential Concern ("COPCs"), and to provide an estimate of the relationship between the extent of exposure to these contaminants and the likelihood and/or severity of adverse effects. The toxicity assessment is accomplished in two steps: hazard identification and dose-response assessment.

The hazard identification is a qualitative description of the potential toxic effects of the COPC.

Carcinogens

The U.S. EPA has developed a qualitative weight-of-evidence classification system to define a chemical's potential to cause carcinogenic effects. This classification is based on carcinogenicity results from long-term animal tests, epidemiological studies, and other supportive data. The U.S. EPA separates chemicals into five distinct categories, ranging from Group A, chemicals for which there is sufficient evidence to consider the chemical carcinogenic to humans, to Group E, chemicals for which there is evidence of noncarcinogenicity in humans. Chemicals which have been classified in Group A through Group C were included in the quantitative risk assessment. Slope factors and unit risk values are calculated by the U.S. EPA's Carcinogen Assessment Group (CAG) and verified by the Carcinogen Risk Assessment Verification Endeavor Workgroup (CRAVE). The slope factor is 95% upper bound estimate of the slope of the dose/response curve for a particular study or group of studies involving the exposure of humans or animals. These slope factors are used to estimate the risks associated with oral exposure to potential carcinogens. Unit risks, or the risk associated with lifetime exposure to 1 ug/m^3 of a chemical in air, were used to evaluate inhalation exposures.

Noncarcinogens

The determination of the health hazards associated with exposure to noncarcinogens is made by comparing the estimated chronic intake of a compound with the reference dose (RfD) for oral exposures or the reference concentration (RfC) for inhalation exposures. For the MIG/DeWane risk assessment, chronic RfDs and RfCs were used for the determination.

A chronic RfD is defined as an estimate of a daily exposure level, or in the case of RfCs, a daily exposure concentration, for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of harmful effects during a lifetime exposure. The RfDs and RfCs are specifically developed to be protective of long term exposure to a compound. A RfD or RfC is typically derived by applying a safety factor on of one or more orders of magnitude to a dose thought to represent a no observed adverse effect level (NOAEL) in humans. The magnitude of the uncertainty factors that are applied when developing and RfD or RfC is

dependent on the quality and applicability of the available animal and human toxicity studies.

Subchronic RfDs and RfCs have been developed for some chemicals to assess exposures between two weeks and seven years. Acute RfDs and RfCs are developed on a case by case basis for even shorter exposure durations, such as those associated with an accidental fall into the leachate surface impoundment.

An acute RFD was developed from the one-day health advisories published by the U.S. EPA (EPA, 1992). For the chemicals of concern detected in the surface impoundment, one-day health advisories were available for antimony and beryllium. A minimum risk level ("MRL") was developed by the Agency of Toxic Substances and Disease Registry ("ASDDR"). This MRL is based on a NOAEL of 5mg/kg (day and a Lowest Observed Adverse Effects Level ("LOAEL") of 50 mg/kg/day associated with neurological effects in rabbits (ATSDR, 1991). These values were used in the assessment of surface impoundment exposures. An acute RFD was not available for iron. The chronic RFD used in the risk assessment is a provisional value developed by the U.S. EPA Superfund Health Risk Technical Support Center.

Section 4: Risk Characterization

Potential cancer risks are assessed by multiplying the estimated lifetime average daily intake (LADI) of a carcinogen by its slope factor ("SF"). This calculated risk is expressed as the probability of an individual developing cancer over a lifetime and is an estimated upper-bound incremental probability. Cancer risks initially are estimated separately for exposure to each chemical for each exposure pathway and receptor category (i.e., adult or child). Separate cancer risk estimates then are summed across chemicals, receptors, and all exposure pathways applicable to the same population to obtain the total excess lifetime cancer risk for that population. Cancer risk estimates are provided in scientific notation; 1×10^{-6} is equivalent to 1E-6, which equals 0.000001.

The potential for adverse effects resulting from exposure to a noncarcinogen is assessed by comparing the estimated chronic daily intake ("CDI") or Subchronic Daily Intake ("SDI") of a substance to its chronic or subchronic RfD. This comparison is made by calculating the ratio of the estimated CDI or SDI to the corresponding RfD to yield a hazard quotient ("HQ"). HQs that are associated with similar critical effects (e.g., liver damage) should be summed together to obtain a hazard index ("HI") for that effect, whereas HQs for different critical effects should be kept separate. However, for screening purposes, HQs are commonly summed across all chemicals, exposure routes, and pathways applicable to a given population to obtain an HI for that population.

For evaluating noncarcinogenic effects, U.S. EPA defines acceptable exposure levels as those to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety (EPA 1989). This acceptable exposure level is approximated by a HI less than or equal to 1.0.

Non-cancer risks are usually assessed by calculating a hazard quotient, which is the ratio of the estimated exposure to the RfD as follows:

where:

HQ	=	Hazard quotient;
CDI	=	Chronic daily intake (exposure); and
RfD	=	Reference dose (acceptable daily intake).

These risks are summarized in the following table

Summary of Carcinogenic and Noncarcinogenic Risks

MIG/DeWane Landfill
Belvidere, Illinois

RECEPTOR	MEDIA-SPECIFIC HAZARD INDEX (unitless)	DISTRIBUTION OF NONCARCINOGENIC RISK BY MEDIA (%)	MEDIA SPECFIC CANCER RISK (unitless)	DISTRIBUTION OF CARCINOGENIC RISK BY MEDIA (%)
TRESPASSER				
Soil/Sediment				
Onsite Soil	1.2E-05	0%	5.1E-08	1%
Offsite Soil	4.6E-03	0%	2.7E-08	1%
Drainage Channel Soil	2.6E-05	0%	3.0E-09	0%
Intermittent Stream Sediment	0	0%	1.2E-08	0%
Leachate Seep Sediment	5.9E-03	0%	0	0%
Surface Water				
Intermittent Stream Water	1.8E-01	2%	2.2E-06	64%
Leachate Seep Water	7.8E-01	10%	1.1E-06	31%
Acute Exposure				
Surface Water Impoundment Water	1.0E+00	13%	9.7E-10	0%
Surface Water Impoundment	5.8E+00	75%	2.5E-09	0%

Air					
Onsite Ambient Air	6.7E-04	0%		5.3E-08	2%
Offsite Ambient Air	5.5E-04	0%		4.7E-08	1%
Totals=	**7.8+00**	100%		**3.5E-06**	100%
CURRENT RESIDENT					
Air					
Ambient Air	1.1E-03	100%		2.8E-07	100%
Totals=	**1.1E-03**	100%		**2.8E-07**	100%
FUTURE RESIDENT					
Air					
Indoor Air from landfill gas/groundwater	4.1E+00	100%		1.1E-03	100%
Ambient Air	1.5E-03	0%		3.6E-07	0%
Totals=	**4.1E+00**	100%		**1.1E-03**	100%

Source: Illinois EPA's Baseline Risk Assessment (CDM, 1997)

Ecological Assessment

The Ecological Risk Assessment ("ERA") evaluates the likelihood that adverse ecological effects may occur or are occurring at a site as a result of exposure to single or multiple chemical or physical stressors. Risks result from contact between ecological receptors (i.e., plants, animals, fish) and stressors (i.e., chemicals) that are of sufficiently long duration and of sufficient intensity to elicit adverse effects. The primary purpose of the ERA is to identify and describe actual or potential onsite conditions that can result in adverse effects to present or future ecological receptors.

The ERA focused on primary ecological stressors and exposure pathways identified as being associated with the site. The primary stressors were identified as having potential to cause ecological stress include many inorganic and organic chemicals in (1) onsite surface water, (2) leachate surface impoundment and intermittent stream sediments, and (3) leachate seep, drainage channel, and onsite and offsite surface soils. Preliminarily identified potential chemical stressors

include a wide variety of chemicals including inorganics (metals), volatile organic compounds, and semi-volatile organic compounds, such as polychlorinated biphenyls ("PCBs"), polycyclic aromatic hydrocarbons ("PAHs"), and pesticides.

The final baseline ERA identified risks to representative ecological receptors from exposure to selected chemicals of concern as follows.

- Aquatic biota such as aquatic plants (algae), zooplankton (daphnids), sensitive bethic invertebrates, and sensitive fish species are likely to be adversely impacted by: (1) copper and cyanide, and to a lesser degree, 4-methylphenol cobalt, lead, nickel, vanadium, and zinc in surface water of the intermittent stream; and (2) cadmium and cyanide, and to a lesser degree, bis(2-ethylhexyl)phthalate, pyrene, nickel and zinc in sediment of the intermittent stream and possibly Kishwaukee River sediments. These effects are likely to include mortality, reproductive effects, and growth effects for sensitive species.

- Terrestrial plants may be at risk from: (1) direct contact with drainage channel surface soil due to elevated (phytotoxic) concentrations of cadmium, lead, vanadium, and to a lesser extent, nickel and zinc; (2) direct contact with leachate surface soils due to elevated (phytotoxic) concentrations of vanadium and zinc, and to a lesser extent, cadmium, lead and nickel; and (3) direct contact with onsite and offsite surface soils due to elevated (phytotoxic) concentrations of vanadiumand zinc, and to a lesser extent, cadmium, lead, and nickel. These effects are likely to include reduced growth, germination, or reproductive success.

- Terrestrial soil-dwelling animals (e.g., soil invertebrates, reptiles, small burrowing mammals, songbirds, and carnivorous birds and mammals) are expected to be at low risk from exposure to surface soil in the drainage channels, leachate areas, offsite and onsite. Risks are location-dependent and influenced by variables such as diet, season, foraging area, and mobility of consumers, and by the level of contamination in surface soil and food items. Ecologically significant exposure through ingestion of contaminated food items is considered to be unlikely because the primary COCs in surface soil do not bioaccumulate to a great degree.

Summary of Chemical Properties for Final Chemicals of Concern (COCs)

Chemical or Class of Chemical	Bioaccumulation Potential	Bioavailabilitly and Toxicity	Environmenta Persistence
Polychlorinated Biphenyls (PCBs)	Variable, but most highly chlorinated PCBs (e.g., Aroclor 1254, 1260) accumulate to a very high degree in biological tissues. Primarily stored in fatty tissues of animals. Terrestrial plants take up less chlorinated PCBs more rapidly than highly chlorinated PCBs (Eisler, 1986)	For aquatic biota, low solubility decreases bioavailability and toxicity of highly chlorinated PCBs.	Persistence increases with chlorination. Highly chlorinated PCBs very resistant to bacterial degradation and are very persistent in the environment
Polycyclic Aromatic Hydrocarbons (PAHs)	Variable, but most animals and microorganisms can metabolize PAHs to products that ultimately experience complete degradation (Eisler 1987). Rapid uptake and rapid metabolism/elimination is expected in most cases.	Toxicity increases with molecular weight (MW) in most cases. Low solubility decreases bioavailability of high MW PAHs. Bioavailability in sediments is generally low. Some PAHs are carcinogenic to mammals.	Generally persistent. Primarily degraded by photolysis and microbial degradation. Degradation slow in sediments that are anoxic with little light penetration.
Pesticides/Herbicides	Variable but many, especially chlorinated hydrocarbons (e.g., aldrin, dieldrin) accumulate to a very high degree in biological tissues. Organochlorine compounds (e.g., chlordane) are readily taken up but more easily metabolized. Most are stored in fatty tissues of animals.	Most highly toxic an readily bioavailable to aquatic and terrestrial biota.	Most chlorinated hydrocarbons are persistent in the environment because they are resistant to degradation. Organochlorines such as chlordane are generally short-lived in water but may persist in soils.
Volatile Organic Compounds	Low bioaccumulation potential.	Generally low toxicity. Several are common laboratory contaminants. Detections in surface medial should be viewed with caution due to expected volatilization and rapid degradation.	Not persistent. Easily degraded.
Inorganics	Highly variable. Mercury only metal that is expected to bioaccumulate to a high degree. Others, such as copper and zinc, can accumulate to a moderate degree in aquatic biota. Terrestrial biota less likely to accumulate most metals. No reported bioaccumulation for cyanide.	Variable toxicity. Mercury and cadmium highly toxic. Copper, silver, zinc and several others moderately to highly toxic, depending on receptor. Bioavailability in aquatic systems decreased with increasing water hardness and dissolved organic carbon. Acid volatile sulfides mitigate toxicity in sediments for some metals. Cyanide highly acutely toxic—rapid degradation minimized chronic toxicity potential.	Metals highly persistent, not degraded. Cyanide not persistent in surface water but may persist in groundwater (Eisler 1991).

Basis for Action

The response action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of pollutants or contaminants or hazardous substances from this Site into the environment and which may present an imminent and substantial endangerment to public health or welfare and/or the environment.

VIII. Remedial Action Objectives

To address the problems identified in the RI and the remedial response actions needed for each Superfund site, the remedial action objectives must be identified first. The remedial response objectives for the MIG/DeWane Landfill Site are based on the exposure levels and risks associated with contamination from the landfill and the leachate surface impoundment. The remedial response objectives consider:

- Site Characteristics that delineate the fate and transport of contaminants and pathways of exposure;
- Human and environmental receptors; and
- The associated short-term and long-term human health and environmental effects.

To meet these broad goals, more focused remedial actions objectives must be identified and then the various possible remedial actions to meet these objectives must be evaluated, as occurred in the FS.

The remedial action objectives identify the problems associated with the site such as: site-specific chemicals of concern, media of concern, potential exposure pathways, and remediation goals. The remedial action objectives are based on the RI and baseline risk assessment results, as well as the appropriate state and federal environmental regulations. The remedial action objectives will be achieved through specific remedial response actions. Further details on the remedial action objectives are included in the FS document.

The following remedial action objectives, based on the findings of the RI, have been identified for the MIG/DeWane Landfill Site:

- Mitigate potential human and ecological risks associated with leachate seeps, including leachate waters, sediments, and corresponding offsite precipitation
- Mitigate potential human exposure risks associated with the surface impoundment liquids and sediments.

- Minimize the impacts of precipitation runoff on the surface water and sediment quality of the drainage channels and intermittent stream.

- Minimize leachate migration potential to groundwater.

- Mitigate potential human risk associated with the offsite migration of landfill gas towards residential homes west of the landfill.

- Restrict future development on the landfill, as well as in the soil borrow pit west of the landfill.

- Groundwater will be returned to drinking water quality through landfill containment/control measures and natural attenuation, and will comply with water quality criteria for Class I aquifers established under Illinois 35 IAC Part 620 (Groundwater Standards).

- Address potential future impacts to surface water from migration of contaminated groundwater.

- Address potential ecological risks associated with leachate seeps runoff to the intermittent stream, drainage channels to the north, and the Kishwaukee River.

The remedial action objectives, as indicated immediately above, will result in response actions that provide for waste containment, leachate generation reduction, reduction and control of landfill gas, and the minimization of contaminant migration to groundwater and surface waters through landfill capping. The necessary response actions were considered through the development of various remedial alternatives. The response actions and aspects of the remedial alternatives are included below.

Landfill Source Waste Containment

The landfill capping/containment remedial response action will address the remedial action objectives associated with both prevention of direct contact with refuse and control of leachate. In addition, any leachate contaminated surface soils, as well as contaminated surface impoundment sediments will be placed under the cap. Capping reduces the migration of leachate constituent from the buried waste to groundwater, surface water, and air resulting from leachate surface seeps or downward percolation. It is an effective containment technology that prevents direct human contact and reduces surface infiltration and the volume of corresponding leachate generation. Leachate seep sediment will be covered/capped as part of the final remedy. Surface water runoff controls to enhance capping integrity and minimize potential refuse and seep contact with precipitation will also be implement as part of the landfill capping.

The Illinois EPA is recommending a multi-component cap system composed of a vegetative layer, a soil protective layer, drainage layer, and a geosynthetic clay cover with a geomembrane be installed over the entire landfill landfill. The engineering specifications for the selected material will be based on U.S. EPA guidance.

Leachate Removal

The leachate seeps that were historically observed coming from the landfill have been significantly reduce by the placement of the interim cap during the Interim Response Measures activities in the early 1990s. However the interim cap was only a partial cap that does not meet the requirements of Part 811 of 35 Illinois Administrative Code for landfill cover systems. Observed leachate seep conditions are believed to be a result of the localized accumulation of leachate in combination with an inadequate depth of soil cover. It is believed that the installation of an adequate cap system over the landfill would prevent the future accumulation of leachate (i.e., the permeability of the landfill base would be greater than the cap), which would result in the gradual dissipation of the current leachate accumulation and mitigate long-term seep problems.

The planned active leachate removal scenario includes continued operation of the existing system located within the eastern portion of the landfill, in combination with the construction of a complementary drainage system within the major seep areas along the western portion of the landfill. The existing leachate removal system would continue to be operated as is within the eastern portion of the Landfill. A leachate holding tank system would have to be installed as a replacement for the closure of the surface impoundment.

Landfill Gas Generation and Migration

The remedial action objectives will also result in remedial response actions that will reduce and intercept gas mitigation from the landfill. According to the baseline risk assessment, landfill gas migration poses an exposure concern for the future residents scenario if residential homes are constructed in the IRM soil borrow pit area west of the landfill, and possibly pose a risk of chronic exposure to homes built near the borrow pit. Horizontal landfill gas migration away from the landfill is also believed to have contributed to the low-level groundwater impacts to the west, northwest of the landfill. The gas extraction remedial alternatives include passive and active venting systems.

Offsite landfill gas migration to the west was identified as a migration pathway of concern in the baseline risk assessment in the event future residential development occurs within the IRM borrow pit area to the west (not feasible given the current deed restriction). Since residential homes located further west of the IRM borrow pit area may still represent a potential exposure pathway of concern, a landfill perimeter gas monitoring system (proximate to and/or outside of the landfill perimeter fence) was installed along the western boundary of the refuse burial. The

monitoring system was installed in order to provide additional data to evaluate the extent of offsite gas migration. Presently, the monitoring system is being used to assess the effectiveness of the collection system in the active mode at controlling landfill gas migration to the west. It will continue to provide effectiveness information during the Remedial Action ("RA") phase.

Passive gas venting systems are specifically designed to collect and direct the subsurface movement of landfill gases using vertical pipe vents or trenches. Passive venting systems can be installed either within the interior or around the perimeter of a landfill. Individual pipe vents are limited in their area of influence, but can be an effective and inexpensive means of reducing localized landfill gas pressures within and around the perimeter of a landfill when installed as a system of multiple vents. Trench collection vents are typically more effective in controlling the lateral movement of landfill gas if keyed into low permeability materials or extended to the water table. Both vertical wells and a trench, or a combination, can be applied for venting in the vicinity of the landfill site. Passive gas vents to be installed within the landfill can be upgraded to active gas extraction.

The baseline risk assessment defines the potential future residential exposure scenario associated with landfill gas migration to the west. Landfill gas sampling near and in the subdivision during early 1999 determined that methane gas posed a possible hazard of flammability in some homes. To address this problem, an active gas collection trench was installed along the western boundary of the landfill. The trench was constructed down to near the water table and intersected the permeable vadose zone sand seams that have been identified as extending to the west of the landfill site. The permeable vadose zone sand seams represent the expected pathway of landfill gas migration (i.e., conceptual model for the Site). As previously mentioned, the function of the active gas collection trench is to intercept the pathway of offsite landfill gas migration to the west towards the residential homes.

In addition to the gas collection/interceptor trench, six vertical gas extraction were installed near the eastern boundary of the subdivision and the western boundary of the borrow pit. These gas extraction wells are being used to remove landfill gas from underneath the subdivision.

The two mechanisms for offsite migration include convection and diffusion. Gas flow due to convection (i.e:. based on subsurface pressure gradients) represents the primary mechanism for offsite gas migration. Diffusion migration, which results from the movement of gases from areas of higher to lower concentrations (i.e., based on subsurface concentration gradients) is limited in the distance that it will propagate. Horizontal gas migration due to diffusion is typically limited to less than 100 feet.

Groundwater Remediation via Monitored Natural Attenuation

Groundwater has not been identified in either the RI or the baseline risk assessment as a media of concern from a human or ecological exposure perspective for purposes of screening general response actions and corresponding remedial technologies. Low levels of various leachate

constituents were measured in groundwater downgradient of the landfill. A small number of VOCs (primarily vinyl chloride and benzene), inorganic compounds (primarily iron and manganese), and total chlorides are in marginal exceedence of their respective Illinois Class I groundwater quality criteria. Although groundwater was not identified as a media of concern, this ROD requires a reassessment of the risk of VOCs in groundwater and the possible volitalization of VOCs into residential basements.

It should also be noted that alternative groundwater pump and treat or containment approaches, the other general response actions that can be considered for offsite groundwater, would not be any more effective as monitored natural attenuation for the site. It is well documented that pump and treat approaches are not effective at meeting groundwater ARARs or achieving full aquifer restoration that involve meeting cleanup criteria in the low ppb range. In addition, there is ultimately a mass transfer barrier (e.g., desorption) that limits the final groundwater concentrations that can be achieved either by natural aquifer flushing or pump and treat.

U.S. EPA guidance document titled *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites* (1996) identifies monitored natural attenuation as a viable remedy for groundwater, if sufficient information exists that natural processes can achieve the remediation objectives with the implementation of adequate source control measures, monitoring and institutional controls. A more recent U.S. EPA document *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (1997) identifies monitored natural attenuation as a viable approach for lower concentration groundwater impact conditions, and in instances where the remediation time frame to achieve groundwater ARARs would be comparable to existing pump and treat or in-situ treatment technologies.

The groundwater contaminant plume will be addressed using a monitored natural attenuation approach. Source control (i.e., landfill capping) and performance monitoring are fundamental components of any monitored natural attenuation remedy. A network of groundwater monitoring wells will be sampled on a regular schedule to determine the effectiveness of natural attenuation.

The term "monitored natural attenuation" refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site specific remedial objectives within a time frame that is reasonable compared to that offered by other more active methods. The "natural attenuation processes" that are at work in such a remediation approach include physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. Natural attenuation processes may reduce the potential risk posed by site contaminants in three ways:

1. The contaminant may be converted to a less toxic form through destructive processes such as biodegradation or abiotic transformations;

2. Potential exposure levels may be reduced by lowering of concentration levels (through the destructive processes, or by dilution or dispersion); and

3. Contaminant mobility and bioavailability may be reduced by sorption to the soil or rock matrix.

Natural attenuation is being provided in a complementary manner at the site by the combination of the interior landfill environment and the lower permeability glacial till zone present beneath the refuse burial, as well as the higher permeability of the Interface Hydrostratigraphic Unit. This is evidenced by the much lower concentrations of VOCs and chlorides measured in groundwater at the site, versus what was measured in the leachate well samples and what can be considered typical for uncontrolled municipal landfills. Primary natural attenuation mechanisms include the following: adsorption to natural organic carbon content in the unsaturated zone glacial till soils; biodegradation in the vapor and adsorbed soil phases in the unsaturated zone and dissolved aqueous phase in the saturated zone; dispersion of the dissolved phase in the saturated zone; and immobilization/precipitation of metals present in the dissolved phase in the saturated zone resulting from changes in subsurface oxidation/reduction valence states as constituents migrate away from the presence and influence of landfill leachate. Given the existence of monitoring well data from the landfill interior to the Kishwaukee River, the ultimate groundwater receptor, the RI data demonstrate the magnitude of the natural attenuation process.

The RI data support the following conceptual model for the site and what is commonly known about landfill fate and transport mechanisms:

- The fine-grained, low permeability materials underlying the landfill are believed to be impeding the migration of leachate constituents of the Interface and Galena-Platteville Hydrostratigraphic Units. A large portion of the refuse burial occurred above grade and, therefore, neither the refuse nor corresponding leachate is in direct contact with groundwater. Approximately 10 to 25 feet of lower permeability till exist between the base of the landfill and the Interface Hydrostratigraphic Unit. The hydraulic conductivity of the till unit, based on laboratory testing of soil samples collected from natural till soils analogous to what is present at the base of the landfill, is on the order of 10^{-6} to 10^{-7} cm/sec.

- The leachate versus monitoring well data demonstrate that downward leachate migration through the till base soils of the landfill is being impeded and natural attenuation is occurring. Natural attenuation mechanisms (e.g., retardation, adsorption, biological degradation) known to be associated with landfill environments (i.e., interior boundaries of refuse burial) and the low permeability till soils beneath the refuse burial are responsible for minimizing the groundwater impacts immediately downgradient of the landfill.

- The downgradient monitoring well data (total chlorides, in particular, which are not subject to any degradation mechanisms) demonstrate the complementary natural attenuation capacity of the shallow groundwater zones as migration of groundwater leachate constituents occurs

away from the landfill and towards the Kishwaukee River. The primary natural attenuation mechanisms associated with the shallow groundwater zones appear to be dilution, dispersion, and metals precipitation into the native soil matrix.

- The low-level constituents in groundwater have not adversely impacted the water or sediment quality of the Kishwaukee River.

- The following RI findings and conclusions support the conclusion that the site conditions are providing a significant level of natural attenuation capacity and are capable of limiting leachate constituent migration even, possibly, in the absence of additional landfill control measures:

- The reduction in total chloride concentration between the leachate and groundwater demonstrates the natural attenuation mechanism provided by the dilution and dispersion mechanisms of groundwater flow. Average total chloride concentrations decreased from approximately 4,000 mg/L in the leachate to between 160 and 640 mg/L in groundwater around the perimeter of the landfill and 25 to 200 mg/L in downgradient groundwater.

- The primary leachate constituents (e.g., various ketones, aromatic hydrocarbons, and phenols) are virtually absent in the offsite groundwater samples. Most of these compound are considered relatively soluble and mobile in groundwater and, thus, are not typically as prone to subsurface retardation/attenuation mechanisms. The virtual absence of these compounds in offsite monitoring well samples mean downward leachate migration is being impeded, and/or these compounds are being naturally biodegraded or dispersed within the unsaturated or saturated zones beneath the landfill prior to migrating offsite. Biodegradation of ketones and phenols, principal leachate constituents, is a natural attenuation mechanism within the landfill interior and the base till soils beneath the refuse burial, based on their known susceptibility to aerobic biological degradation (and possibly anaerobic biological degradation).

- Mobile organic leachate constituents concentrations in groundwater are low in comparison to corresponding concentrations measured in leachate samples, an indicator that natural attenuation is occurring for these compounds. Only the most mobile and persistent of the organic leachate constituents (e.g., vinyl chloride and benzene) were found at low ppb concentrations in groundwater. At a minimum, the natural attenuation of these compounds in occurring by the dilution and dispersion mechanisms. A level of retardation also likely occurs within the till base soils beneath the refuse burial. The presence of VOCs constituents in groundwater could also be a result of horizontal landfill gas migration, as opposed to vertical leachate percolation, or a combination of both.

- Natural precipitation of metals present in the leachate (e.g., iron and manganese) back into the native soil matrix, due to a shift from an anaerobic environment inside of the landfill to an oxidized state away from the influence of the refuse burial, is a natural attenuation

mechanism between the landfill interior and perimeter groundwater monitoring wells. Inorganic metals appear to be returning to near natural background levels prior to reaching the Kishwaukee River.

- The low concentrations of daughter products cis-1,2-dichlorothene and vinyl chloride in offsite monitoring wells, versus the relative absence of the parent compounds trichloroethene and tetrachloroethene, suggests these leachate constituents compounds are being biodegraded via a reductive dehalogenation mechanism within the landfill interior, probably within the base soils beneath the refuse burial, and possibly within the Glacial Drift and Interface Hlydrostratigraphic units.

The time frame required for monitored natural attenuation to reach Illinois Class I groundwater quality criteria or the cleanup objective for the groundwater migrating to the west-northwest of the landfill through the West Glacial Pathway is estimated to range from 13 to 26 years. This time frame is the same if various additional contingent leachate removal scenarios are implemented. The time frame required for natural attenuation to reach Class I groundwater criteria or the cleanup objectives for the groundwater migrating north of the landfill through the North Interface Pathway under the planned leachate removal scenario and natural attenuation is from 81 to 108 years. When this approach is combined with the contingent leachate removal scenario, the time frame is estimated to range from 54 to 81 years. The difference between the two leachate removal/natural attenuation remediation scenarios meets the criteria of U.S. EPA guidance document on monitored natural attenuation.

As stated earlier in this document, institutional controls are already in place to restrict the use of offsite groundwater by current residential homes to the west of the Landfill. Consequently, water supply wells have not been, and will not be, installed within the residential area to the west, thus removing offsite groundwater as a current human exposure pathway. Per the Boone County Health Department, a permit to install a water-well will not be issued if municipal water is provided by the city.

The groundwater at the site and groundwater in the areas immediately adjacent to the site are not used as a drinking water source. Private drinking wells do exist north of the Kishwaukee River, but groundwater flow north of the river is south towards the river.

The human health risks are effectively addressed by the remediation goals, some of which are now presently being addressed through the landfill gas extraction and interception system. The capping of the landfill will effectively reduce groundwater infiltration through the landfill waste, thus reducing the generation of landfill leachate and gas. The landfill gas is presently being remediated as mentioned above. The landfill cap and a leachate collection system will result in dramatically reduced contamination to groundwater by contaminants such as VOCs. Contaminants presently in the groundwater and soil are apparently undergoing natural attenuation or intrinsic remediation due to the composition and chemistry of the soil.

IX. Description-of Alternatives

The general response actions that were developed for the MIG/DeWane Site were developed to address the various media of concern and the remedial action objectives. The details of how the response actions were developed are included in the FS document. Both the media of concern and the remedial action objectives that were developed and included in the FS are based on the results of the RI and the baseline risk assessment. For all remedial alternatives, the state and federal regulations and ARARs will be complied with and the appropriate U.S. EPA guidance will be followed.

The site area and media (i.e., soil, groundwater) to be addressed by the remedial actions at the MIG/DeWane Landfill include the following:

1. The landfill, which is approximately 47 acres in size, measuring approximately 50 to 55 feet in height, containing an estimated 3,715,200 cubic yards of waste, with an indeterminate volume of leachate and landfill generated gas; and
2. The leachate surface impoundment, which measures approximately 130 feet wide by 130 feet long by 10 feet deep.

The media to be addressed include leachate, landfill gas (methane), groundwater, and leachate soil sediments. In addition, VOCs that may volatilize from the groundwater must be remediated from under the western soil borrow pit. The soil borrow pit is approximately 19 acres in size. The landfill cap, leachate removal, and gas extractions system should reduce the VOC migration to groundwater.

The general response action categories to be addressed are included below and are addressed by the various possible remedial alternatives. It is remedial alternative 4A that is believed to provide for the best over all set of response actions for the following:

- Groundwater
- Buried Refuse/Surface Soils
- Landfill Gas
- Leachate

Capping Alternatives

The capping remedy

There are five (5) main capping remedial alternatives that are included in the FS document. In addition, two of the five main alternatives have sub-alternatives. The Illinois EPA has proposed a 6th capping alternative, designated as Alternative 4A. Alternative 4A is different from Alternative 4 in that it requires that more soil be used in the landfill cap, but not as much soil as proposed by Alternative 5.

Alternative 4 does not meet the Illinois EPA Applicable or Relevant and Appropriate Requirements ("ARARs") for and adequate depth of cover soil. Alternative 5 does meet ARARs but construction/engineering problems apparently do not make this alternative possible. Alternative 4A is a comprise design between the alternatives.

Except for Alternative 1, the remedial alternatives all include additional landfill capping requirements. The landfill cap alternatives are different from each other. Alternative 1, the No Action Alternative, is a baseline for comparison to other alternatives. SARA mandates the inclusion of the No Action alternative.

The following capping options have been developed and are presented by their respective remedial alternative designations:

- Alternative 1 - Alternative 1 represents no additional action, beyond the previous interim remedial measures of 1992/3. The no additional action alternative will be used as a basis for evaluating remedial alternatives against the results of the Baseline Risk Assessment.

- Alternatives 2A and 2B - Alternative 2A would leave the interim remedial measures cap in place and construct an analogous 2-foot compacted clay cap over the side slopes of the landfill. An optional drainage layer could also be installed. Alternative 2B includes all of 2A, plus the addition of a 3-foot protective soil layer over the compacted clay layer.

- Alternative 3A and 3B - Alternative 3A involves the installation of a geosynthetic clay cap (GCL) over the landfill crest to further reduce precipitation infiltration and protect the older interim response measures cap, and 2 feet of compacted soil on the landfill side slopes, with an optional drainage layer. Alternative 3B includes all of 3A, plus the addition of a 3-foot protective soil layer over the GCL.

- Alternative 4 - Alternative 4 involves the installation of a grading layer of no specific depth, over the landfill side slopes, a GCL cap over the entire landfill, a drainage layer over the entire landfill, and 1 ½-foot protective soil layer over the GCL and drainage layer.

- Alternative 4A - Alternative 4A is an option not included in the FS, but an option proposed by the Illinois EPA. This option includes all of Alternative 4, but requires the grading layer to be of a minimum depth of 1-1½ feet and the final protective soil layer to be 30 inches on the crest of the landfill and top of the landfill side slopes, with a minimum of 2 feet of

protective soil layer at the bottom of the side slopes.

- Alternative 5 - Alternative 5 includes all of Alternative 4, but instead of a 1 ½ -foot protective soil layer, it includes a 3-foot protective soil layer.

<u>Common Non-Cap Components of Remedial Alternatives 2-5</u>

The Superfund program requires that the "no-action" alternative be evaluated at every site to establish a baseline for comparison. Under this alternative the Illinois EPA and USEPA would take no further action at the site to prevent exposure to the soil and groundwater contamination. This alternative is applicable to each of the media addressed by the RI/FS.

The common, non-cap, components for Alternatives 2-5 include the following:

- Institutional controls for the Landfill and the Soil Borrow Pit area, west of the landfill. Institutional controls such as zoning restrictions, deed restrictions, and public health regulations restrict development in these areas and not allow for the installation of drinking water wells.
- Removal of all leachate surface impoundment liquids and sediments.
- Natural attenuation/intrinsic remediation of groundwater and institutional controls to meet Illinois and Federal groundwater and surface water regulations.
- Leachate collection system to minimize leachate flow to groundwater.
- Offsite leachate treatment and disposal.
- Landfill gas collection system.
- Leachate and landfill gas monitoring.
- Long-term groundwater monitoring.
- Construction of a landfill surface water diversion system.

<u>Summary of Non-Cap Components Common to Alternatives 2-5</u>

NOTE: Additional specific details of the Common Non-Cap Components for Remedial Alternatives were included above in the Remedial Action Objective section. Details for the the Remedial Alternatives were included above in an attempt to explain how the Remedial Action

Objectives will be met by implementing the Remedial Alternatives.

Construction and operation of a leachate collection and monitoring system: Because leachate has been migrating to and contaminating groundwater and a contaminant plume was detected moving towards the Kishwaukee River, an enhanced leachate collection system will be installed. The leachate collection system will be composed of the present gravity controlled leachate collection system and a few collection trenches located on the landfill in the area of major leachate seeps. The gravity controlled leachate collection system located in the eastern third of the landfill was installed during the original construction of the landfill. The enhanced leachate collection system will mitigate leachate surface leachate seeps, reduce hydrostatic pressure within the landfill, and reduce leachate contamination into groundwater. A localized leachate gravity collection and drainage system will use a system of either permeable bed layers, or passive trenches, and if necessary vertical wells, for the major leachate seep areas.

In general the major seep areas are located on the north and northwestern slopes of the landfill. To intersect major leachate flow areas, passive collection trenches and/or a permeable bed layer consisting of perforated pipe surrounded by highly permeable coarse stone aggregate will be installed across the face of the major leachate seep areas. Also, interior vertical leachate extraction wells used to mitigate the future occurrence of seeps, will be installed in areas where there is a need based on the internal hydrostatic pressure measurements and engineering determinations.

The vertical leachate collection wells will be operated under gravity or artesian conditions for a period of time necessary to reduce localized leachate head buildups to sufficient levels that minimize and stop the seeps. If, however, leachate must be removed in a shorter time frame than can be achieved by gravity operation to mitigate future seeps, or active interior leachate extraction must be implemented as a contingent remedial action measure to address groundwater contamination, surface water (Kishwaukee River) regulations or other ARARs, then vertical leachate extraction wells will be fitted with submersible pumps to perform active extraction for a limited duration until the remedial objectives are met. The conditions that would result in the additional enhancement of the leachate collection system are those that would result in a sustained increase in groundwater contamination, or those that indicate no decrease in groundwater contamination over a specific time interval. The collected leachate will be treated onsite or transported offsite for treatment and disposal. Also, there are additional possible contingent leachate removal options identified in the FS. These options include the following:

- A perimeter trench system can be constructed along key lengths proximate to identified areas of leachate accumulation;
- Horizontal well laterals can be installed along the base of the western portion of the refuse burial area;
- Passive gas vent wells located in identified areas of leachate accumulation can be retrofitted to operate as leachate extraction wells; and
- Any combination of the three leachate removal alternatives described above can be

implemented if the combination is more cost effective than implementing each of alternatives separately.

The additional leachate removal options would be used if either of the following scenarios occurred: (1) design analysis based on the pre-design leachate monitoring data indicates that leachate removal must be accomplished in a shorter time frame to mitigate the seep conditions; or (2) in the event that the corresponding trigger mechanism criteria described below in the Groundwater Monitoring Plan part of this section are exceeded.

The extent of passive leachate collection trenches, permeable interceptor beds, or other contingent leachate removal components as described in the FS will be established as part of the remedial design using additional data obtained during pre-design sampling investigation and study. An engineering evaluation of future seep potential and a leachate head drawdown analysis will occur. The extent of these leachate removal component of the remedial action will be sufficient to collect and convey leachate that flows to the trench, bed, or other leachate management component, mitigate seep potential, dissipate high leachate heads, and work effectively with the cap to meet the remedial action objectives.

The contingent leachate removal scenarios are provided as a contingent response measure that may be performed, based on an exceedance of trigger mechanism criteria. These contingent leachate removal scenarios, if triggered, would continue until piezometer data indicate internal hydrostatic pressures have been sufficiently relieved to either prevent future leachate seep problems or prevent continued migration of leachate constituents to groundwater, with a corresponding reduction in groundwater and soil gas contaminants being observed.

Construction and operation of an active and passive perimeter landfill gas collection, treatment and monitoring program: The landfill gas and treatment collection system will reduce interior landfill pressures which serve as a driving force for gas migration. This system will protect residential homes west of the landfill from potential uncontrolled offsite gas migration, as well as reduce landfill gas pressure within the interior of the landfill, thus protecting the integrity of the landfill cap.

The gas collection system will include a combination of passive vents in the landfill interior and include a gas collection trench along the western edge of the refuse burial boundary. If necessary the passive gas vent wells can become active vents. The western-perimeter gas collection system will initially be operated in an active mode, as is necessary. The gas extraction trench and gas extraction wells have been installed. Gas vapor probes have been installed to monitor gas migration, especially to the area west of the landfill.

Leachate surface impoundment closure: All surface impoundment liquids and a minimum of two feet of sediments will be removed, as was determined to be necessary by the RI sampling. The impoundment liquids will be treated and disposed of offsite. The contaminated sediments will be excavated and consolidated beneath the landfill cap. The surface impoundment will then

be filled with clean soil.

Surface water diversion system: A surface water diversion system will be installed along the landfill side slopes. This system will include drainage ditches around portions of the toe of the landfill, where feasible, and corresponding discharge lines/routing. Erosion control measures, and structures will be implemented where necessary.

Implementation of access restrictions and institutional controls: Institutional controls such its site security fences, zoning restrictions, deed restrictions, and adherence to local ordinances restricting groundwater use will be used to restrict access to the site and contaminated groundwater. Institutional controls including no development on the landfill site, or in the soil borrow pit west of and adjacent landfill will be implemented.

The areas to the north and northwest of the landfill will be designated as a Groundwater Management Zone ("GMZ"). A GMZ is a three dimensional region in which the groundwater must be managed to mitigate impairment caused by the release of contaminants from a site. Groundwater management to mitigate impairment can use various combinations of technology. The groundwater management measures need to be direct measures that contain and remediate groundwater. 35 IAC Code 620.250 allows for the establishment of GMZs within any class of groundwater.

The agricultural field north of the landfill and railroad tracks is located within the Kishwaukee River flood plain. Residential development is restricted and drinking water wells can not be installed. The local/county zoning ordinances and Boone County Health Department regulations can also be used to restrict groundwater drinking well installation. The IRM soil borrow pit property has development deed restrictions.

Natural attenuation/intrinsic remediation of groundwater: To remediate groundwater contamination and insure compliance with Illinois EPA and U.S. EPA groundwater and surface water regulations, numerous remediation components will be implemented. These components include, capping the landfill, reducing gas pressure within the landfill, the removal of leachate, and natural attenuation through the establishment of a GMZ north, northwest of the landfill. The establishment of a GMZ will allow for the natural attenuation of the contaminated groundwater by the natural organic content of groundwater as it flows through the GMZ towards the Kishwaukee River. The natural attenuation occurs when a variety of physical, chemical, or biological processes occur within the soil and groundwater to reduce the mass, toxicity, mobility, volume or concentration of contaminants in the soil or groundwater.

Natural attenuation is being provided at the Site by the combination of the interior Landfill environment and the lower permeability glacial till zone present beneath the refuse burial, as well as the higher permeability of the Interface Hydrostratigraphic Unit. This is evidenced by the much lower concentrations of VOCs and chlorides measured in groundwater at the Site, versus what was measured in the leachate well samples and what can be considered typical for

uncontrolled municipal landfills (USEPA, 1987b). Primary natural attenuation mechanisms include the following: adsorption to natural organic carbon content in the unsaturated zone glacial till soils; biodegradation in the vapor and adsorbed soil phases in the unsaturated zone and dissolved aqueous phase in the saturated zone; dispersion of the dissolved phase in the saturated zone; and immobilization/precipitation of metals present in the dissolved phase in the saturated zone resulting from changes in subsurface oxidation/reduction valence states as constituents migrate away from the presence and influence of landfill leachate. Given the existence of monitoring well data from the Landfill interior to the Kishwaukee River, the ultimate groundwater receptor, the RI data demonstrate the magnitude of the natural attenuation process.

To insure that effective natural attenuation occurs, source control (i.e., landfill capping, leachate surface impoundment leachate and sediment removal) and long-term performance monitoring of the groundwater will be performed. In addition, contingency measures requiring that additional remediation technologies be implemented are incorporated into the remediation process, in case natural attenuation and landfill capping do not result in the remediation objectives being met. For MIG/DeWane, the contingency plan will include an additional leachate withdrawal measure triggered by the exceedence of Groundwater Action Levels included in the Groundwater Monitoring Program part. The contingency plan includes the implementation of one or all of the following: (1) a landfill perimeter trench leachate extraction system, (2) horizontal leachate withdraw wells along the landfill perimeter, and (3) vertical leachate extraction wells within the landfill interior.

Groundwater Action Levels, Target Compounds for Natural Attenuation, and Contingent Leachate Removal: As was stated above in the Baseline Risk Assessment Section, groundwater action levels have been established to trigger a contingency plan for additional leachate removal, if natural attenuation is not effectively occurring. Sampling results from monitoring wells located immediately downgradient of the landfill perimeter will serve as the basis for determining the exceedence of an action level for purposes of triggering the contingent leachate removal plan. Groundwater action levels are specific levels of contaminant concentrations for specific contaminant target compounds. The target compound action levels have been designated as triggers for additional remediation if the action levels are met or exceeded, as determined by groundwater monitoring (see Long-term Groundwater Monitoring below for more details).

The initial groundwater action levels have been established to be protective of surface water, mainly to protect the Kishwaukee River. The baseline risk assessment did not find the groundwater media to represent a completed pathway for contaminants because the groundwater use is restricted. VOCs in groundwater, however, may constitute a potential risk component due to volatilization. An addendum to the baseline risk assessment is being developed to re-examine the VOCs as a potential risk component. Results from the addendum to the baseline risk assessment will be taken into consideration during the remedial design stage, to insure that the any potential risk is adequately addressed by the remedial alternatives.

The groundwater action levels include a 7 VOC target compounds, and each compound has two different groundwater action levels. There are separate groundwater action levels for the north groundwater pathway and for the west pathway. The action levels are based on surface water quality criteria. These target compounds and their respective action levels are presented in the table below.

SURFACE WATER QUALITY CRITERIA

Contaminant of Concern	Acute	Chronic	Human Health (Organisms)	Max. Detected West Pathway	Action Levels West Pathway	Max. Detected North Pathway	Action Level North Pathway
Benzene	5.2 mg/L	0.42 mg/L	*0.071 mg/L	0.011 mg/L	6.3 mg/L	0.012 mg/L	1.37 mg/L
1,1-Dichloroethylene	3.03 mg/L	0.242 mg/L	*0.0032 mg/L	<0.001mg/L	135 mg/L	0.001 mg/L	2.3 mg/L
1,2-Dichloropropane	4.8 mg/L	0.38 mg/L	*0.039 mg/L	0.01 mg/L	0.85 mg/L	0.006 mg/L	0.37 mg/L
Methylene Chloride	17 mg/L	1.4 mg/L	0.34 mg/L	0.01 mg/L	13000 mg/L	<0.001 mg/L	10333 mg/L
Tetrachloroethylene	1.2 mg/L	0.15 mg/L	*0.00885 mg/L	0.007 mg/L	0.88 mg/L	0.002 mg/L	0.18 mg/L
Trichloroethylene	12 mg/L	0.94 mg/L	*0.081 mg/L	0.01 mg/L	2.53 mg/L	0.006 mg/L	0.91 mg/L
Vinyl Chloride	NCE	NCE	*0.525 mg/L	0.012 mg/L	10.58 mg/L	0.028 mg/L	4.77 mg/L

* = Value obtained from the December 22, 1992 Federal Register (Vol. 57, No. 246) pages 60890, 60911, and 60912.

NCE = No Criterion Established

If the concentration level of any of the above target leachate constituents (compounds) meet or exceed the above listed levels, for two quarterly groundwater sampling events within any 4 consecutive quarters, then the exceedance will trigger the contingency leachate removal process that requires that alternative remediation measures be implemented. An evaluation of the situation will determine which elements of the contingency plan will be implemented. The contingency leachate removal would continue until groundwater contaminate levels return to the previous or lower levels.

It should be noted that in addition to the groundwater action levels based on surface water criteria, the Illinois EPA believes that the use of additional groundwater action levels based on the MCLs for COCs identified in the RI, baseline risk assessment, and the baseline risk assessment addendum results should be considered during any pre-remedial design study, and/or the remedial design stage. This issue has been raised based on concerns relative to the nearby subdivision and the Class I groundwater requirements. The groundwater action levels above are based on surface water criteria that are two to six orders of magnitude greater than the maximum detected levels for the seven listed compounds. It would also appear that it may be more appropriate for additional action levels to be set at the level that would clearly indicate that the monitored natural attenuation remedy is showing a decrease in contaminant concentration after a certain period of time. Using these criteria the action levels for the COCs should be closer to the

maximum detected levels detected. Any changes to the appropriate target levels will be specified after completion of the baseline risk assessment addendum. Additionally if a decrease in COC concentrations are not detected within the specific time frame, then additional leachate withdraw methods should be instituted.

Contingent leachate removal options identified in the FS include:

- A perimeter trench system could be constructed along key lengths proximate to identified areas of leachate contamination.

- Horizontal well laterals could be installed along the base of the western portion of the refuse burial.

- Passive gas vent wells located in identified areas of leachate accumulation could be retrofitted to operate as leachate extraction wells.

- Any combination of the three leachate removal alternatives described above could be implemented if the it is more cost effective than each of them separately.

Long-term groundwater monitoring: The long-term groundwater monitoring program will provide information on natural attenuation's progress towards achieving the clean-up objectives. The 7 chemicals of concern to be included in the groundwater monitoring program, as noted immediately above in the natural attenuation section, include: benzene: 1,1- Dichloroethylene; 1,2-Dichloropropane; methylene chloride; tetrachloroethylene; and vinyl chloride. The groundwater monitoring program would determine the effectiveness of the landfill cap, and the leachate and gas collection systems for the mitigation of leachate migration from the landfill interior. The plan to initiate additional leachate extraction from the landfill interior and/or perimeter would be triggered if target groundwater contaminants meet or exceed the groundwater action levels under the circumstances described above.

Because the extent of groundwater contamination is limited, it is believed that the groundwater cleanup objectives can be attained through these containment, removal, and natural remediation measures without directly treating the groundwater, within a time frame that is reasonable as compared to active measures.

The Groundwater Monitoring Program details will be refined during the Remedial Design stage. The groundwater monitoring program is based on the ARAR requirements of 35 IAC Parts 620 and 811/814. The objective of the monitoring program would be to assess progress toward the attainment of groundwater ARARs by monitored natural attainment.

Groundwater monitoring will be performed on a quarterly basis for at least the first 2 years in order to develop a data base of baseline conditions for comparative purposes and to observe any seasonal variations that may occur. The first 2 years of sampling and follow years of quarterly

sampling will be performed to evaluate monitored natural attenuation progress. Monitoring parameter will include VOCs, target inorganics, relevant water quality and natural attenuation evaluation parameters, and other parameters as approved by the Illinois EPA and U.S. EPA. The evaluation or "indicator" parameters will be monitored in addition to the chemicals of concern.

In general these parameters depend on the attenuation mechanisms that are being relied on to cleanup the groundwater (see Remediation Objectives section). For reductive dechlorination the indicator parameters should include dissolved oxygen, nitrate, iron (II), sulfate, methane, oxidation/reduction potential, and chloride as well as the expected degradation products (e.g., cis-DCE, vinyl chloride, etc.).

As discussed above, baseline groundwater concentrations at each of the monitoring wells would be determined using sampling results from eight consecutive quarterly monitoring events performed over the initial 2-year period following completion of the Remedial Action construction activities. The objective of this initial sampling over a 2-year period would be to gather sufficient level of data to develop a statistical representation of baseline groundwater quality and potential variations. The initial target constituent list for statistical baseline analysis would include organic and inorganic parameters that exceed Class I groundwater quality criteria for at least one baseline sampling event. However, as discussed above, the monitoring parameters from the initial baseline sampling events would include a more exhaustive list of organic, inorganic, and water quality and natural attenuation evaluation parameters as proved by the Illinois EPA and U.S. EPA. The target constituent list can be amended, as appropriate by the Illinois EPA and U.S. EPA based on continued long-term monitoring program results.

The long-term monitoring groundwater program would focus on the evaluation of monitored natural attenuation progress towards achieving identified chemical-specific ARARs (i.e., Class I groundwater quality criteria), as well as the effectiveness of the source control measures toward the mitigation of continued leachate migration from the landfill interior. The source control measures and monitored natural attenuation would be considered effective if groundwater contaminant levels and leachate levels within the landfill interior gradually decrease at a predetermined rate without resulting in a further degradation of overall groundwater quality.

Leachate piezometers would be installed within the interior of the landfill during the Pre-Design phase. Leachate potentiometric levels would be monitored during this phase to determine the baseline hydraulic conditions. These piezometers would continue to be monitored after the implementation of the remedy (i.e., completion of the landfill cap) to determine the dissipation rate of the accumulated leachate within the landfill interior. The monitoring frequency and the criteria for evaluating the dissipation rate would be established as part of the Remedial Design.

The chosen remedial alternative meet the remedial action objectives by combining active leachate removal and landfill capping to mitigate the leachate seep conditions and reduce future infiltration into the landfill. The reduction in infiltration rates would serve to both prevent the recurrence of future seep conditions by dissipating the accumulation of leachate levels within the

interior of the landfill, as well as enhance the natural attenuation capacity of the site hydrogeology. As previously mentioned, the current natural attenuation capacity for the landfill has already prevented more significant impacts to groundwater from occurring. A reduction in future infiltration rates would accelerate the monitored natural attenuation remediation process for groundwater towards attaining groundwater chemical-specific ARARs (i.e., Class I groundwater quality criteria). The landfill gas control system would address the potential future residents scenario described in the baseline risk assessment associated with uncontrolled landfill gas migration.

Summary of Landfill Capping Alternatives

Construction of a new cover/cap over the entire landfill will minimize the infiltration of precipitation into the landfill. The covering or capping of the landfill is a general remedial response action that is also described as a containment option. State and Federal regulations and ARARs (i.e., 35 IAC 811/814 and 40 CFR 258) require municipal landfills to be adequately covered. The required, relevant and appropriate environmental regulatory standards for the landfill capping action can be used to address the remedial action objectives associated with both the prevention of direct contact with refuse and the control of leachate. Landfill capping reduces the generation of leachate and migration of leachate, contaminants from the leachate and buried landfill refuse to the groundwater and surface waters, such as the Kishwaukee River. By minimizing the downward infiltration of precipitation into the landfill, landfill capping is an effective containment technology that prevents direct human contact with the landfill waste and reduces the infiltration of precipitation (i.e., snow, rain) and thus the corresponding leachate generation.

Each of the alternatives is listed and discussed in greater detail below:

Alternative 1 - No Action

Estimated Cost: none *Operation & Maintenance Activities: none*

As stated previously, the No-Action Alternative is required by the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). Its purpose is to allow comparison of this alternative to other alternatives and to conditions that currently exist and that will likely exist in the future. No active remedial response actions would occur beyond those that presently exist at the site. This alternative would include leaving the interim response cap in place without the implementation of additional capping or control technologies (e.g., gas extraction or leachate collection). The current institutional controls include such items as fencing for site security, zoning and health ordinances that restrict land and groundwater usage would continue. Deed restrictions for land use are already in place for the soil borrow area west of and adjacent to the landfill. The soil borrow area is also part of the Groundwater Management Zone for site remediation.

The No Action Alternative would allow for the continuation of groundwater contamination for an indefinite period of time, leachate seeps, exposed refuse, surface water contamination, landfill gas generation and migration, and allow the leachate surface impoundment to remain.

The No-Action Alternative would not directly reduce the current and possible future levels of leachate within the landfill. The partial interim cap was previously constructed as a short term emergency procedure has not been protected from the effects of numerous rounds of freezing and thawing, desiccation, burrowing animals, plant root penetration, and erosion due to the absence of additional protective layers. Continual unprotected exposure of the partial landfill cap to the natural elements will allow, and may already have allowed, the infiltration of precipitation into the interior of the landfill, resulting in the generation of additional leachate. The present absence of an adequate cap on the landfill crest and the side slopes can and has resulted in the localized accumulation and seeping of leachate. The absence of adequate soil cover and improper grading to address surface water run-off does pose a long-term damage problem for the side slopes. Isolated areas of exposed refuse and erosion gullies have been observed. The uncontrolled release of landfill gas through the inadequately covered side slopes, and possibly through the weakened areas of interim cap, can cause stress to the current vegetative cover on the landfill. The stress to the vegetative cover could further exacerbate the erosion and cause further deterioration of the present soil cover.

The No-Action alternative, as described above for the present partial landfill cap does not comply with 35 Illinois Administrative Code ARAR requirements 811 and 814, and it does not meet the more limited and less protective requirements of 807, in that soil cover depth does not meet the minimum requirement of two feet of soil on all areas of the landfill, in that only the landfill crest 17 acres is covered with two feet of soil. Some areas on the side slopes of only 6 inches of soil or less. As a result of the present cap inadequacies, source control of contaminants located within the landfill would not occur because the landfill side slopes do not have an adequate depth of soil cover. The inadequate soil depth would allow for precipitation to filter through the landfill, thus generating more leachate and causing additional groundwater contamination, In general, this alternative is not protective of human health and the environment to the extent required by the regulations.

Alternatives 2A and 2B

Alternative 2A Landfill Cap Details

Total Alternative 2A Costs include:

Cap Construction	$4,545,600
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000

Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222,311
Operation and Maintenance	$3,089,862
Total 2A Costs	$13,748,624

Alternative 2A involves leaving the older interim cap in place as is on the crest of the landfill, but extending the original cap to include the side slopes in order to provide adequate soil cover to mitigate leachate seeps. This would require that the side slopes would first be graded to provide a more uniform slope and run-off control to minimize future erosion damage to the cap. After grading, a two-foot compacted clay cap would be constructed over the graded landfill side slopes to cover the horizontal extent of buried refuse. A geosynthetic drainage layer would be installed on the side slopes only. Next a minimum of six inches of top-soil would be placed over the compacted clay to support vegetative growth to minimize erosion.

Alternative 2B Landfill Cap Details:

Total Alternative 2B Costs include:

Cap Construction	$8,866,250
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000
Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222.311
Operation and Maintenance	$3,089,862
Total 2B Costs	$20,387,108

Alternative 2B is a variation that includes all of 2A plus the inclusion of a thirty-inch soil freeze-thaw protection layer (plus the minimum of six inches of topsoil vegetative layer) over the landfill crest and side slopes. The three-foot frost protection layer would protect the two-foot compacted clay cap layer from the effects of freezing and thawing that over time may damage the underlying two-foot compacted clay layer. The average soil frost/freeze depth for winters in northern Illinois is three feet. The State of Illinois requires the three-foot freeze protection later for municipal landfills, as per 35 IAC Part 811. The 811 regulations were instituted to replace inadequacies found in the older 807 regulations. In addition to the additional depth of soil, between the two soil layers a geosynthetic drainage net layer would be installed on both the top and side slopes of the landfill. The drainage layer would allow for precipitation that accumulates in the freeze protection layer to drain away from the underlying clay layer. Under the appropriate circumstances, a one-foot sand drainage layer could be substituted for the geosynthetic net.

Alternatives 3A and 3B

Alternative 3A Landfill Cap Details

Total Alternative 3A Costs include:

Cap Construction	$7,277,650
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000
Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222,311
Operation and Maintenance	$3,089,862
Total Alternative 3A Costs	$18,277,056

In addition to the non-cap remedial action components for landfill gas and leachate remediation, noted above, Alternatives 3A and 3B include the following additional landfill cap options.

Alternative 3 A involves extending the interim cap (2ft. of compacted clay) from the top of the landfill onto the side slopes in order to provide adequate soil cover to mitigate leachate seeps. The side slopes would be graded to provide a more uniform slope and to control storm water runoff to minimize future erosion damage to the cap. A two-foot compacted layer of clay soil would be constructed to form a cap over the landfill side slopes to insure adequate cover of the buried refuse. On top of the two-foot side slope cap a six-inch top-soil layer for vegetation would be placed. The vegetative layer will minimize the absorption of precipitation, thus reducing the generation of leachate within the landfill. A thin geosynthetic net drainage layer would be placed only on the side slopes. These components are common to Alternative 2A.

In addition, over the top of the two-foot thick compacted clay interim cap, a second layer would be placed. This second layer is a Geosynthetic Clay Layer (GCL). The GCL is a relatively thin layer of processed clay (typically bentonite) either bonded to geomembrane or fixed between two sheets of geotextile or geotextile and a geosynthetic geomembrane called a flexible membrane liner (FML). A geomembrane is a polymeric sheet material that is impervious to liquid as long as it maintains its integrity. A geotextile is a woven or non-woven sheet of material less impervious to liquid than a geomembrane, but more resistant to penetration damage.

The inclusion of a GCL secondary barrier over the two-foot compacted interim cap would reduce the infiltration of precipitation (snow melt and rain water) into the underlying clay cap, thus protecting the integrity of the interim cap layer from moisture damage, and resulting in the reduction of leachate generation and groundwater contamination. Alternative 3A includes all of Alternative 2A plus the GCL barrier.

Alternative 3B Landfill Cap Details

Total Alternative 3B Costs include:

Cap Construction	$9,687,250
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000
Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222,311
Operation and Maintenance	$3,089,862
Total Alternative 3B Costs	$21,719,025

Alternative 3B includes all of Alternative 3A plus a thirty-inch freeze protection soil layer with a six-inch top soil vegetative layer on top of the two-foot compacted clay interim cap layer, the geonet drainage layer, and the GCL barrier layer. The details of the thirty-inch freeze protection soil layer with the six-inch vegetative layer are included above in Alternative 2B. The GCL layer would not be extended over the landfill side slopes.

Alternative 4

<u>Alternative 4 Landfill Cap Details</u>

Total Alternative 4 Costs include:

Cap Construction	$6,815,950
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000
Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222,311
Operation and Maintenance	$3,089,862
Total Alternative 4 Costs	$16,829,193

This option includes the previously installed interim cap (two-feet of compacted clay), located only on the top of the landfill, and not on the slopes. The side slopes would be graded to provide a more uniform slope and run-off control to minimize future erosion damage and provide a proper surface for the installation of the Geosynthetic-Clay Layer (GCL). The GCL used will contain a treated bentonite (clay) layer sandwiched between a woven, geotextile fabric component layer and a geomembrane component on top. A geosynthetic drainage net layer would be installed over the GCL and the entire landfill. The geo-net layer would provide drainage for precipitation that would infiltrate the landfill from snow or rain, thus further reducing leachate generation and groundwater contamination. Because the GCL would not provide sufficient counterweight to prevent leachate seeps from leachate already accumulated within the landfill, an additional soil layer consisting of a minimum soil depth of 18 inches will be used to cover the GCL. The leachate monitoring data collected during the Pre-Design phase would be used to specify the soil types, thickness, and any compaction requirements for the cover layer in order to provide adequate protection against the recurrence of leachate seeps. The eighteen (18) inch soil cover protective layer will include a twelve layer soil layer combined with six inches of topsoil as a vegetative layer.

Alternative 4A

Alternative 4A Landfill Cap Details

Total Alternative 4A Costs include:

Cap Construction	$7,461,950
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000
Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222,311
Operation and Maintenance	$3,089,862
Total Alternative 4A Costs	$17,475,193

Alternative 4A is an option not included in the FS. This option is proposed by the Illinois EPA as a modification to Alternative 4 to assure that the detailed design for the site remedy is developed to satisfy ARARs, remedial action objectives, and Illinois EPA performance criteria, so that the performance, implementability, and cost-effectiveness of the remedy can be optimized. Alternative 4A is a compromise between Alternatives 4 and 5, with the difference being that the soil cover be a minimum of 30 inches in depth on top of the landfill and be allowed to taper to 24 inches minimum at the toe of the landfill. The 24 inches at the toe of the landfill will be allowed due to slope restrictions caused by the landfill cap's proximity to the property boundaries and physical barriers such as railroad tracks and fiber optic underground cables. The geomembrane, as the top component of the Geosynthetic Clay Layer ("GCL"), will protect the bentonite layer of the GCL from root penetration, desiccation, erosion impacts, and burrowing animals. The proposed soil protective layer depths are expected to provide a safeguard against long-term environmental degradation of the GCL, provide the necessary depth for good vegetative root growth, minimizing erosion and thus protecting the GCL. Good vegetative growth is necessary to minimize soil erosion of the cap. Before the GCL is placed, the old interim cap, consisting of two feet of compacted clay on the crest of the landfill will be repaired where necessary, and the side slopes will be backfilled and covered with a minimum of 12 inches of compacted soil for the cap's subsoil/grading (foundation) layer. Up to six inches maximum depth of soil may be removed from the two feet of clay crest, to be used on the sideslopes. This work will be undertaken to insure adequate cover soils over areas that have eroded, and/or contain leachate seeps or have exposed refuse. The subsoil/grading layer will be properly prepared to protect the GCL from the landfill contents and items in the soil such as large dirt clods, rocks, and roots. Alternative 4A will substantively meet the Illinois EPA regulations and ARARs requirement for 35 IAC, Subpart C, Section 811.314(c)(2).

Alternative 5

Alternative 5 Landfill Cap Details

Total Alternative 5 Costs include:

Cap Construction	$8,142,750
Leachate Piezometer and Gas Probe Installation	$88,600
Leachate Bed Construction	$1,220,000
Gas Collection System	$419,000
Closure of Surface Impoundment	$163,250
Engineering and Construction	$4,222,311
Operation and Maintenance	$3,089,862
Total Alternative 5 Costs	$18,792,446

Alternative 5 is technically identical to both 4 and 4A, in all aspects except it includes a protective soil cover of 36 inches in depth over the top of the GCL, and does not require a minimum 12 inches of subsoil. Alternative does include a grading/subsoil layer of about 6 inches in depth. This alternative complies with Illinois regulations and ARARs. It differs from Alternative 4 which requires a soil cover of only 18 inches and Alternative 4A which requires a soil cover of only 30 inches on top of the landfill, with a decrease to a 24 inches at the bottom of the landfill slopes.

X. Comparative Evaluation of Alternatives

This section represents an analysis of the remedial alternatives listed above. The analysis provides information to compare alternatives and demonstrate satisfaction with the CERCLA remedy selection requirements and the nine evaluation criteria. Capping Alternative 4A, in combination with common non-cap components of the Remedial Action, meets the nine criteria better than any other capping options that were combined with the common remedial components.

The common non-cap components of the Remedial Action, in combination with the respective capping options, address the remedial action objectives by mitigating the leachate seep conditions, preventing direct contact with buried refuse and impacted liquids and sediments, providing institutional controls that would not allow future development of the landfill and in the IRM soil borrow pit on the west because of the contaminated groundwater, intercepting uncontrolled gas migration towards the residential homes to the west, and minimizing future migration potential of leachate constituents to groundwater.

For the common non-cap components of the remediation there is no comparative analysis since all of the non-cap components of remediation are used in conjunction with each of the capping options. The common non-cap components of the remediation are considered to be a shared or common component of each capping option, and it is the combined remedial components of each capping remedial alternative that are evaluated using the nine criteria.

Analysis

Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

Alternative 1: Alternative 1 (No Action Alternative) would not be protective of human health and the environment because the alternative would not prevent exposure to site contaminants both on-site and off-site. Alternative 1 only includes leaving the IRM cap in place, institutional controls , and monitored natural attenuation. Even though Alternative 1 would provide some level of overall protectiveness, it would not address leachate seeps or completely control landfill gas migration even though the active gas system has already been installed. Gas can migrate through the landfill sideslopes where there is inadequate soil cover. The present cap is inadequate to reduce the infiltration of precipitation to the interior of the landfill and would not further reduce the migration of potential contaminants to groundwater. The contaminated groundwater could pose a risk to the Kishwaukee River ecosystem. Leachate seeps can still be observed at the landfill. In addition, areas of exposed refuse, and leachate contaminated soils are evident along the landfill side slopes where insufficient soil cover presently exists. Trespassers could be at risk due to the surface impoundment. Leachate that could flow off-site could also pose a risk.

Alternative 2A: Alternative 2A would not be protective of human health and the environment since it may not provide a reliable means of preventing exposure to site contaminants over time. It would not allow for adequate protection of the landfill cap's compacted clay layer from various types of damage including freeze-thaw cycles, desiccation, animal burrowing, plant root penetration, and erosion. The integrity of the landfill cap would be a problem. Also, this alternative does not provide for adequate storm water drainage, nor adequately reduce precipitation infiltration that could result in additional leachate contaminants moving into the groundwater. It would, however, be expected to reduce infiltration rates versus the initial uncontrolled conditions by 74% to 95%. Localized areas of leachate seeps may continue to be a potential problem. Gas migration could be a potential problem due to the inadequate depth of the soil cover and the porous nature of soils. Alternative 2A is a single barrier cap. Also, this cap may not be able to eventually meet the Class I groundwater criteria, nor-prevent leachate seeps.

Alternative 2B : The Alternative 2B landfill cap would be expected to be provide more protection than alternative 2A, because it is a two barrier cap that includes a protective soil layer to cover

the compacted clay layer. However, the cap may not be overall protective. Alternative 2B would be expected to reduce infiltration rates by only approximately 89%. This level of expected infiltration reduction is one of lowest, and therefore one of the least protective rates. This infiltration rate level of reduction would not meet the MCL for vinyl chloride. Also, alternative 2B Would result in implementability problems because the cap would extend offsite.

Alternatives 3A and 3B: Alternatives 3A and 3B and their capping approaches would be more protective of human health and the environment than Alternative 1, in that both considerably reduce infiltration of water into the landfill, and offer some improvement over the single barrier clay cap system of Alternative 2A. It is estimated that Alternative 3A would reduce infiltration from between 90% to 99% under optimum conditions. It should be feasible to ultimately attain Class I groundwater quality criteria for either cap options. However, 3A would not meet the Class I groundwater criteria for vinyl chloride that requires at least a 93% reduction in infiltration rates, therefore it may not be adequately protective of human health and the environment. Alternative 3A, however does not include a protective soil layer over the GCL on the landfill crest, nor for the compacted clay soil on the landfill sideslopes. Alternative 3A is subject to degradation from freeze-thaw cycles, and erosion, leachate seeps and burrowing animals on the sideslopes. With only 6 inches of soil over the GCL, it would not allow for adequate vegetative growth to hold the soil in place, thus resulting in erosion problems and exposing of the GCL. Without an adequate protective soil layer, the long-term integrity of the cap may be in question. Also, the cap would not provide sufficient counterweight to prevent leachate seeps. Alternative 3B could result in a precipitation reduction of only about 94%, which is borderline for eventually in meeting the vinyl chloride MCLs . This is in the mid-range for precipitation reduction. The cost for Alternative 3B is the highest of all capping options.

Alternative 4: Alternative 4 may be protective of human health and the environment. The reduction of infiltration into the landfill is expected to be 97% to 99%. It should be feasible to ultimately obtain Class I groundwater criteria with this cap, if cap integrity can be maintained. There is concern, however, that the proposed 18 inch protective soil layer will be inadequate to maintain the long-term integrity of the GCL and protect it from freeze-thaw cycles. There also is some concern that the cap may not provide sufficient counterweight to prevent leachate seeps. This capping option is the second least expensive.

Alternative 4A: Alternative 4A would be protective of human health and the environment; and possibly the most protective. The reduction of precipitation into the landfill would be expected to be between 97% and 99%. The cap would be protective of human health and the environment and play a major role in cleaning the groundwater ultimately to Class I groundwater criteria levels, by effectively reducing leachate generation and contaminate migration. This cap option provides an adequate protective soil layer depth for the GCL component of the cap against the effects of freeze-thaw cycles, thus maintaining cap integrity. The cost of this capping option falls within the mid-range of costs.

Alternative 5: Alternative 5 would be protective of human health and the environment. The